UNIVERSITY OF MORATUWA
SRI LANKA

DESIGN MODELING AND SIMULATION OF A REPEATERLESS OPTICAL FIBER NETWORK FOR SRI LANKA

Submitted in partial fulfillment for the degree of Masters of Engineering in Electronics and Telecommunication

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The work presented in this dissertation has not been submitted for the fulfillment of any other degree

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DEDICATION

I dedicate this Dissertation with a lot of respect to my lovely late Mother who directed me to achieve the best possible education through a lot of dedication and hard work.

It is also with reverence and respect that I remember my Father, my school - Thurstan College and University of Moratuwa for the guidance given me at all times to achieve my goals and aims and providing me with the postgraduate course that I receive.

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I should express my gratitude to ARTIS Software Corporation for providing me an evaluation copy of OptSim Software Tool for simulating and evaluating the designed Network.

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ABSTRACT

A reliable and wideband telecommunication network is a vital infrastructure development, where wide band services such as ATM, ADSL and IP based services could be supported. In Sri Lanka, the requirement of this kind of an optical network is very significant as other operators also can share the capacity of the network for transporting their traffic. On the other hand the network problems such as excessive BER (Bit Error Rate) etc are experienced after its construction. In order to avoid such limitations in the network, the network needs to be modeled on appropriate software tools and run with designed network parameters, so that the desired BER could be ensured.

During the initial phase of the study, the total telephone demand by year 2015 was estimated as nearly 2 million subscribers. This was estimated through the world trend for telephone subscribers together with economic indicators such as GNP and GDP.

The Nodes of the Network was determined based on the present distribution of customers in the County. In this case all the Tertiary Switching Center areas and the Secondary Center Areas where the customer base is more than 2.5% of total customers were taken as the main nodes of the network. In addition Jaffna and Baticaloa were also taken as nodes considering the potential growth of traffic in northern and eastern parts of the Island.

The Gravity model and Earlang's B formula, traffic tables, were used to find the traffic between nodes and the number of circuits between nodes. Based on the traffic distribution between nodes, a part of the network was proposed as a fully reliable Ring Network, while other nodes are connected through extended links. The IP traffic, which is thought to be the major traffic flow in the future, were estimated considering the broadband Internet growth in the country. Also the traffic, which are expected to be migrated from traditional PSTN to IP Network were identified and estimated to find the total bandwidth requirement of the network by year 2015.

The number of wavelengths in the proposed Network were decided based on the final bandwidth requirement. This resulted an island wide network consisting of WDM Ring Network having 08 wavelengths that basically covers the southern part of the country and two other extensions having a wavelength each to northern and eastern parts of the country. The Colombo and the Kandy nodes were selected as Full Fiber Terminal Stations as most of the traffic flow between these two nodes. Wavelengths are added and dropped at each branch station based on the traffic volumes between these nodes.

The wavelengths were selected such that the space between adjacent wavelengths is 0.8nm to avoid nonlinear effects and cross talks. The G.655 non-zero dispersion fiber was selected to mange the dispersion and non-linear effects. DFB and APD are the Source and the Detector respectively to suit long haul transmissions having narrow spectral widths and also to meet better sensitivity at the receiver.

The proposed Network is a Repeaterless Optical Network, where the Power Budget of the longest Segment, Kandy – Matara, of 280km was designed without employing a physical repeater, which needs power feeding. This was achieved using Raman Amplifiers as line repeaters and Erbium Doped Fiber Amplifiers (EDFA) as Boosters and Pre-Amplifiers. The Power Budget has been prepared for all other Segments as well based on appropriate configurations. Also the BER objective of 10^{-9} was ensured for the longest Optical Line Section of Colombo – Kandy via Matara, in which a couple of express wavelengths are assigned for carrying traffic between Colombo and Kandy. The Performance Budget was prepared for long Optical Line Sections and the calculated BER was found as better than 10^{-9}. This has been further confirmed by the Eye Diagrams after simulating the Network on the OptSim Network Simulator developed by ARTIS Software.

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ABBREVIATIONS

ADP	-	Avalanche Photo Diode
ADSL	-	Asymmetric Digital Subscriber Line
ASE	-	Amplified Spontaneous Emission
BER	-	Bit Error Rate
BS	-	Branch Station
CR	-	Calling Rate
DCF	-	Dispersion Cut-off Fiber
DFB	-	Distribution Feed Back
DSF	-	Dispersion Shifted Fiber
DSL	-	Digital Subscriber Line
EDFA	-	Erbium Doped Fiber Amplifier
EOL	-	End of Life
ES	-	Extension Station
FFTS	-	Full Fiber Terminal Station
FWM	-	Four Wave Mixing
GDP	-	Gross Domestic Product
GNP	-	Gross National Product
IP	-	Internet Protocol
ITU	-	International Telecommunication Union
NF	-	Noise Figure
NI	-	Net Income
NZ-DSF	-	Non Zero Dispersion Shifted Fiber
OADM	-	Optical Add Drop Multiplexer
OLS	-	Optical Line Section
OSNR	-	Optical Signal to Noise Ratio
PC	-	Personal Computer
PCM	-	Pulse Code Modulation
PMD	-	Polarization Mode Dispersion
PSTN	-	Public Switched Telephone Network
RA	-	Raman Amplifier
SLT	-	Sri Lanka Telecom
SNR	-	Signal to Noise Ratio
SPM	-	Self Phase Modulation
SRS	-	Stimulated Raman Scattering
SSC	-	Secondary Switching Center
STM	-	Synchronous Transport Mode

TDM	-	Time Division Multiplexing
TRC	-	Telecommunication Regulatory Commission
USB	-	Universal Serial Bus
VOIP	-	Voice Over Internet Protocol
WDM	-	Wavelength Division Multiplexing